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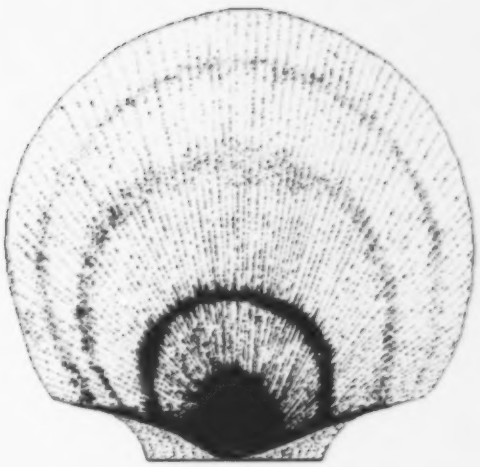
Maritimes Region
Canadian Science Advisory Secretariat
Science Advisory Report 2005/072

STOCK ASSESSMENT REPORT ON SCALLOPS (*PLACOPECTEN MAGELLANICUS*) IN SCALLOP PRODUCTION AREAS 1 TO 6 IN THE BAY OF FUNDY



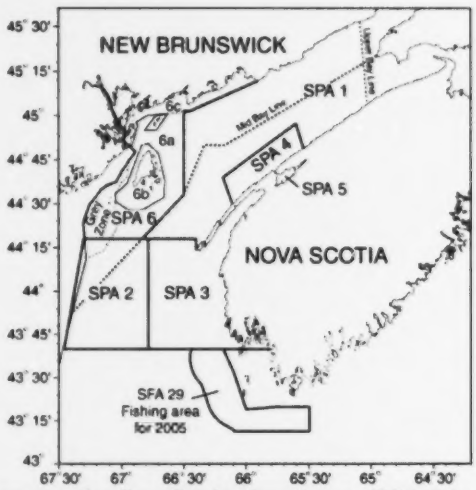


Figure 1. Scallop Production Areas (SPAs) in the Bay of Fundy. Refer to full detail map in Figure 42 (last page) for place names.

Context

The sea scallop Placopecten magellanicus occurs only in the northwest Atlantic Ocean from Virginia north to Labrador. Within this area, scallops are concentrated in persistent, geographically discrete aggregates or "beds", many of which support valuable commercial fisheries. The larger beds are found offshore and in the Bay of Fundy. Scallops in different beds, and in different areas of large beds, show different growth rates and meat yields.

Unlike many commercial scallop species, the sea scallop has separate sexes. Male scallops develop a white gonad in the summer months, while female gonads are bright red. Eggs and sperm are released into the water and fertilization takes place in the sea. Spawning begins in late August to early September, and the larvae drift in the water for almost a month before settling to the bottom in October.

The Bay of Fundy area is fished by the Full Bay and the Mid-Bay licensed fleets. Full Bay vessels are 45' to 65' and Mid-Bay vessels are generally between 30' to 45'. Full Bay licensed vessels are permitted to fish all the Bay of Fundy. The Mid-Bay license holders have access to the New Brunswick side and portions of the Nova Scotia side of the Bay of Fundy to the Mid-bay line and a portion of Scallop Production Area (SPA) 2. There are also 16 Upper Bay Licences restricted to the upper reaches of the bay. The fishery has been managed using limited entry, gear size limits, seasonal closures, minimum shell height, meat count and individual meat weight restrictions. The gear width limit is 5.5 m with ring size of not less than 82 mm inside diameter. Quotas were introduced in 1997. Total allowable catches (TACs) are set and landings are reported in terms of meat weights (adductor muscles).

SUMMARY

All of Bay of Fundy

- The surveys were conducted with a DF0-funded commercial vessel this year due to the unexpected loss of the government research vessel that has been used for Bay of Fundy scallop surveys. There was no opportunity to conduct comparative surveys between the government and commercial vessels. The scallop fishing industry supports the continued use of commercial vessels for the surveys because of the increased efficiency in covering the area.
- Objectives and associated reference points are beginning to be developed for these fisheries. Discussions between the fishing industry and DFO to develop reference points for the scallop fisheries in the Bay of Fundy need to be continued.
- In order to maximize yield-per-recruit, the impact of fishing practices on the mortality of recruits and pre-recruit scallops needs to be investigated.
- Research and monitoring to establish the relationship between scallop biomass and future recruitment success is required.
- Research and monitoring to determine the conditions leading to episodic die-offs is required.
- The Full Bay Scallop Fleet recommends that additional government funding needs to be provided for scallop research.

SPA 1A

- Landings were 322 t against a TAC of 400 t for the 2004/2005 season.
- Commercial catch rates have been declining from the peak in 2002.
- Survey estimates indicate that the larger than average 1998 year-class has been fished down with no strong year-classes evident in the survey size frequencies for upcoming years.
- A fishing strategy of 100 t in SPA 1A for 2005/2006 and 2006/2007 will likely result in median exploitation rates (0.18 and 0.18) at or below 0.2 which could allow the population biomass to increase slightly.

SPA 1B

- Landings were 228 t against a TAC of 200 for the Full Bay Fleet 2005/2006 season, and 206 t against a TAC of 200 for the Mid and Upper Bay fleets 2005 season.
- Commercial catch rate has declined the last two years, but is still above the median level.
- Survey estimates indicate there are two above average pre-recruit year-classes, however the pre-recruit year-class that appeared above average last year appears about average this year. The advice is to maintain the present quota until the contribution of these year-classes is better defined.

SPA 2

- This area is considered to be marginal for scallop habitat.
- There is no scientific advice available for this area.

SPA 3

- Landings in 2005 were 208 t against a TAC of 200 t. An interim TAC of 50 t was set for the 2005/2006 season and unlike recent years fishing occurred in October in 2005.
- Commercial catch rates averaged 16.7 kg/h in 2005, compared to 22.1 kg/h in 2004 and were just above the median catch rate for the series (14.5 kg/h).
- The 2005 survey index (1.4 kg/tow) indicated that the biomass of commercial size scallops declined after 2002, but remains just above the median (1.3 kg/tow) for the ten-year survey series.
- There appears to be little sign of recruitment for 2006.
- Based upon the survey trends, the population appears to be stable at the 150 to 200 t catch level with the possibility of an above average 2004 year-class that could recruit to the fishery within St. Mary's Bay in 2008.

SPA 4

- Landings in 2004/2005 were 535 t against a TAC of 550 t. An interim TAC of 200 t has been set for the 2005/2006 season which opened 1 October 2005.
- Commercial catch rates in 2004/2005 (21.8 kg/h) declined from 2003/2004 (38.6 kg/h) and were near the median over the whole time-series (21.3 kg/h). Mean catch rates in October 2005 (12.2 kg/h) are less than half the mean for October 2004 (27.0 kg/h).
- Survey numbers indicate that the stronger than average 1998 year-class has been fished down and there are no indications of any substantial recruitment for the next two to three years.
- The population model predicts that the current TAC of 200 t will result in a median exploitation rate of 0.26 and a decline in population biomass.
- A fishing strategy of 150 t in 2005/2006 and in 2006/2007 has a 0.50 probability of resulting in exploitation rates at or below 0.2 which could allow the population biomass to increase slightly.

SPA 5

- Landings in 2005 were 13.3 t against a TAC of 10 t.
- Commercial catch rate in 2005 (26.1 kg/h) was lower than in 2004 (32.1 kg/h) but still above the median for the 1977 to 2005 series (21.0 kg/h).
- Survey estimates indicate that the commercial size portion of the population (126/tow) is just above the median (123/tow) but little recruitment is expected for the next two years.
- The TAC for 2006 should not exceed the average over the low abundance periods (1997 to 1999) of 10 t.

SPA 6

- Landings to 7 November 2005, were 83 t against a TAC of 195 t.
- Landings have been in the range of 80-90 t per year for the last three years under a TAC of 195 t.
- Commercial catch rates for the Full Bay fleet have been fluctuating with low effort. CPUE for the Mid Bay Fleet is fluctuating at a lower rate at or above the 1993-2005 median level.
- Effort has decreased by 57% over the last 7 years and is below the median level.
- Due to vessel problems, there was no DFO survey in SPA 6 in 2004. A survey with a commercial vessel in 2005 only covered part of SPA 6B due to time constraints.

- Most of the stock indicators show no signs of good recruitment, and a stock of fully recruited scallops that is being fished down.
- Catch should not exceed 80 t in 2006.

DESCRIPTION OF THE ISSUE

A meeting of the Regional Advisory Process was held 24-25 November 2005 at the Ramada Hotel, in Dartmouth, N.S., to review the 2005 scallop fishery and assess the status of the scallop stocks in Scallop Production Areas 1 to 6 in the Bay of Fundy as well as to provide the scientific advice for the 2006 fishery. Specifically, the meeting was to address:

The assessment of the status of the scallop stocks, including;

- An analysis of all available commercial and survey information.
- For SPA 1 (8-16 mile Digby Area) and SPA 4, application of the assessment model described in Smith et al. (2003).
- For SPA 1 (8-16 mile Digby Area) and SPA 4, a review of interim advice provided for 2005/2006 and recommendations for 2006/2007.
- For the rest of SPA 1, SPA 3, SPA 5 and SPA 6, the provision of advice for 2006.
- The Inshore Scallop Science Advisory Report documenting the results of the assessment.

The definition and application of potential candidates for decision rules and reference points;

- The difficulty of providing scientific advice in terms of the setting of TACs without having decision rules and reference points has been identified as a serious issue in previous Stock Status reports for these management areas.

The change in survey vessel in 2005;

- The Canadian Coast Guard vessel *J.L. Hart* which has been used to conduct the surveys since 1989 was unexpectedly retired from service in late 2004 due to structural problems thus leaving the program with out a survey vessel. A tender was put out for an industry vessel to replace the *CCGV J.L. Hart* and the fishing vessel *Royal Fundy* was awarded the contract to continue the survey program. No comparative tows were conducted between the *FV Royal Fundy* and *CCGV J.L Hart*, because of the sudden departure of the *CCGV J.L. Hart*. The standard survey 4-gang Digby drags were used on the *FV Royal Fundy* and all survey protocols followed on the *CCGV J.L. Hart* remained the same. Analysis of data from SPA 4 suggested that the indices from the *FV Royal Fundy* survey were comparable to those from the *CCGV J.L. Hart* surveys (see results on page 21).

ASSESSMENT

SPA 1 – Inner/Upper Bay of Fundy

SPA 1 covers most of the mid to inner Bay of Fundy. It is fished under three classes of scallop licences: Full Bay licences, which can fish anywhere in the Bay of Fundy; Mid Bay licences which can fish North of the Mid Bay line; and Upper Bay licences, which can fish East of the Upper Bay line (refer to detailed map on last page, Figure 42).

In 2001, the Full Bay fleet changed the quota year for SPA 1. It now runs from October 1 to September 30. The Mid and Upper Bay fleets remain on a calendar year, but split their quota into two seasons, Jan to April, and August to December.

In 2002, SPA 1 was split into SPA 1A and SPA 1B to accommodate a recruitment pulse that was located in SPA 1A that was only accessible to the Full Bay fleet.

SPA 1A – South West Bay of Fundy

The Fishery

The 2004/2005 quota for Full Bay licence holders in SPA 1A was 400 t. This was down from the 1200 t level in 2002/2003, but still above the long term average. The fleet did not, however, reach this quota.

Landings to November 7th were 322 t for the Full Bay licence holders (2004/2005 fishing year).

Landings (meats, t) Full Bay

Year	Avg. 97-01	2001/ 2002[1]	2002/ 2003[2]	2003/ 2004	2004/ 2005	2005/ 2006[3]
TAC (t)	240	700	B: 1200	B: 700	B :400	B :50
Landings	210	745	913	464	322	1

1 Starting Oct. 1 2001 the Full Bay Fleet fishing season changed from a calendar year to Oct. 1 to Sept. 30.
2 Full Bay TAC was split into SPA 1A and SPA 1B in 2002/03.
3 Interim TAC, Landings to November 7, 2005.

Landings in SPA 1A have shown two large peaks; one in 1990 and a recent one in 2003 with landings currently declining (Figure 2). The 1990 peak was seen throughout the Bay while the recent one was confined to SPA 1A. Landings declined to low levels between these peaks.

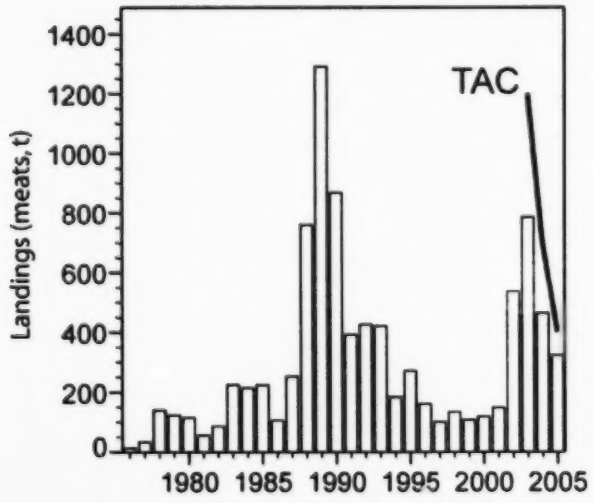


Figure 2. Scallop landings (meats, t) in SPA 1A.

Resource Assessment

Catch per unit effort (CPUE) in SPA 1A declined from a high in the late 1980's to a low in 1997. With the large 1998 year-class recruiting to SPA 1A, it peaked again in 2002, and is now declining (Figure 3).

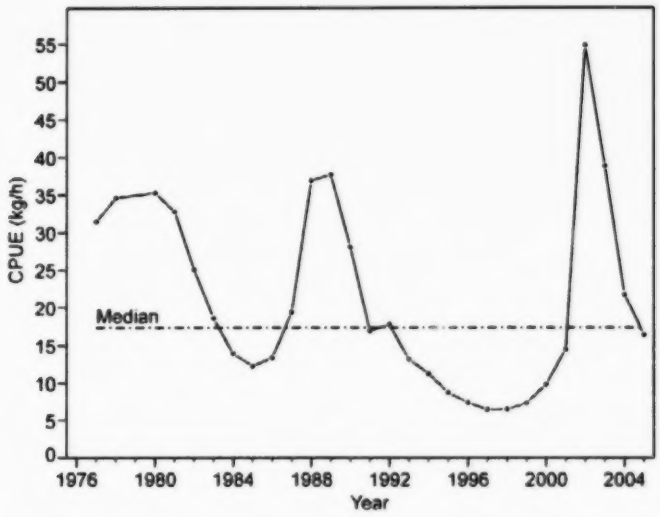


Figure 3. Commercial catch per unit effort (kg/h) for scallops in SPA 1A.

In SPA 1A, **resource surveys** have been conducted annually since 1981 in the 8 to 16 mile area off Nova Scotia. Up to 2003 the surveys were conducted in May-June, but the expanding distribution of lobster traps in the area necessitated rescheduling the survey to August-September. The survey vessel had mechanical problems in 2004, resulting in a shortened survey in September-October.

The 2005 survey had the most complete coverage of any of the modern surveys in this area (Figure 4).

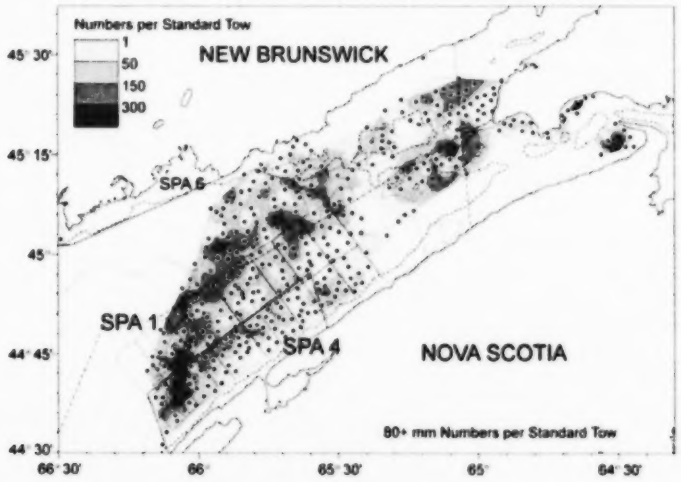


Figure 4. Numbers of scallops 80 mm shell height or greater and station locations for the 2005 scallop survey.

The mean catch per standard tow in this area is still declining from the recent peak (Figure 5), with no strong year-classes evident in the survey size frequencies.

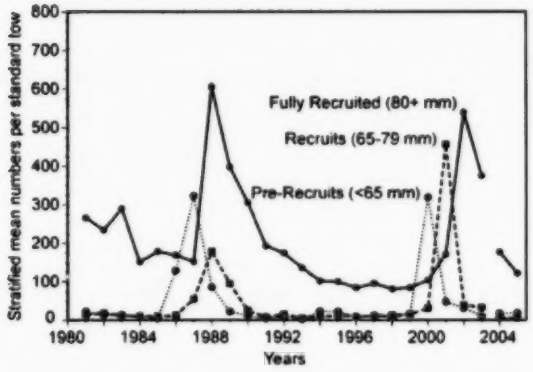


Figure 5. Survey indices (mean no./std. tow) for the 8–16 mile area. The break in the survey series indicates the change in timing of the survey. Surveys were conducted in June from 1981 to 2003 and in August/September in 2004 and 2005.

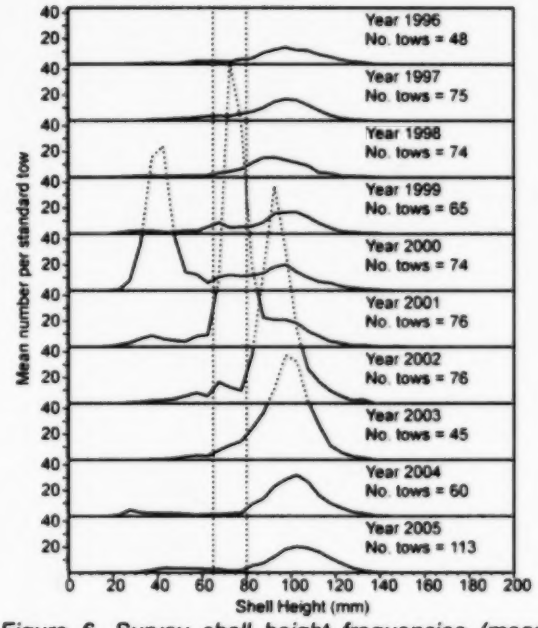


Figure 6. Survey shell height frequencies (mean number per standard tow) for the 8-16 mile area of SPA 1A, which has had consistent coverage through the time series. Surveys were conducted in June from 1981 to 2003 and in August/September in 2004 and 2005.

The size frequency distribution from the surveys shows the 1998 year-class in the 2000-2005 surveys as it recruited to the fishery and was fished down (Figure 6). Since it started to recruit to the fishery in late 2001, this year-class has supported the fishery in SPA 1A. It has been fished heavily and the abundance of scallops > 80 mm shell height has now declined close to the low levels observed in the 1994 to 2000 period.

The population model described in Smith et al. (2003) was used to analyze the survey and commercial catch data and estimate natural mortality and population biomass. The model was revised in 2004 to improve its ability to forecast population size for the following year. Differences between predicted and estimated biomass in 2002 partly reflect the increase in growth rate noted in 2001. A constant growth function was assumed for this model. The other reason for the difference between the two sets of estimates for this time period may also be due to imperfect corrections for the changing relative behaviour of the lined and unlined survey gear when densities are high. Further analysis of the relative selectivity of the survey gear will have to be conducted to solve this issue. The predicted mean biomass for the start of the 2006/2007 season was based on a catch of 100 t for 2005/2006 (Figure 7).

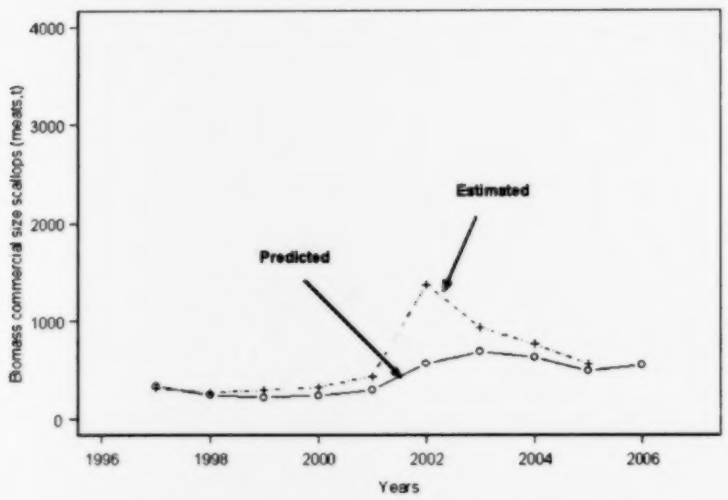


Figure 7. Comparison of predicted biomass from the previous year with the estimated biomass of commercial size scallops in the current year. Scallop Production Area 1A with the 8 to 16 mile area as an index of abundance.

Conclusions and Advice

In last year's assessment, exploitation rate was suggested as a fishery indicator with an upper limit reference point of 0.2 set based on empirical evidence from previous assessments (Lavoie 2004). Given the boom-and-bust cycles observed for this fishery, this indicator was recommended for periods of weak recruitment and low stock biomass. In the table below, a catch of 100 t in 2005/2006 is expected to result in an exploitation rate of 0.18. With all of the uncertainties contained in the model, a catch of 100 t has a probability of 0.42 of exceeding 0.2. For 2006/2007 a catch of approximately 100 t would result in a median exploitation rate of 0.18 with about a 0.45 chance of exceeding 0.20. The model predicts that a fishing strategy of 100 t catch for this season and next season would result in a modest increase in population biomass after this year's fishery and next year's fishery. All catches below these levels should result in small increases in population biomass.

		Catches in 2006/2007				
Catch in	Pr(e>0.2)	Pr(e>0.2) (exploitation)				
2005/06	(exploitation)	50 t	100 t	150 t	200t	250 t
100 t	0.42 (0.18)	0.16 (0.09)	0.45 (0.18)	0.77 (0.36)	0.89 (0.54)	0.95 (0.73)
200 t	0.81 (0.35)	0.30 (0.11)	0.55 (0.23)	0.81 (0.46)	0.90 (0.69)	0.96 (0.92)
300 t	0.93 (0.53)	0.43 (0.16)	0.64 (0.31)	0.84 (0.63)	0.93 (0.94)	0.97 (0.99)

A fishing strategy of 100 t in SPA 1A for 2005/2006 and 2006/2007 will likely result in exploitation rates (0.18 and 0.18) at or below 0.2 which could allow the population biomass to increase slightly.

There are no signs of above average recruitment for the next few years, so fishing above this level will decrease the biomass.

SPA 1B – Northern/Upper Bay of Fundy

The Fishery

The Full Bay quota in SPA 1B for 2004/2005 was 200 t which was the same as in 2003/2004. The Mid and Upper Bay fleets also had a quota of 200 t in 2005, a 50 t increase from the last 2 years. The quotas were exceeded in SPA 1B.

In SPA 1B the landings were 228 t for the Full Bay (2004/2005 fishing year), 157 t for the Mid Bay and 50 t for the Upper Bay fishers (2005 fishing year). Landings by all fleets remain above long term median levels.

In 2004 the remaining quotas for SPA 1B and 6 were combined in August, with most of the combined quota taken in SPA 1B; this resulted in 2004 landings higher than the initial SPA 1B quota.

Landings (meats, t) Full Bay

Year	Avg. 97-01	2001/ 2002[1]	2002/ 2003[2]	2003/ 2004	2004/ 2005	2005/ 2006[3]
TAC (t)	240	700	B: 100	B: 200	B: 200	50
Landings	210	745	B: 33	B: 210	B: 228	2

1 Starting Oct. 1 2001 the Full Bay Fleet fishing season changed from a calendar year to Oct. 1 to Sept. 30.
2 Full Bay TAC was split into SPA 1A and SPA 1B in 2002/03.
3 Interim TAC, Landings to November 7, 2005

Landings (meats, t) Mid and Upper Bay

Year	Avg. 97-01	2002	2003	2004	2005
TAC (t)	66	100	150	150	200
Landings	66	186	212	261[1]	206

1 Remaining quotas in SPA 1 and 6 combined Aug. 2, 2004 with most of the combined quota coming from SPA 1.

The Mid-Bay and Upper-Bay vessels were not required to keep logbooks until 1996, so their earlier catches cannot be broken down by SPA. Landings by Statistical District for Districts 24, 40, 43, 44, 48 and 79, (coast of Bay of Fundy from St. John, N.B. to Morden, Nova Scotia) were used to estimate Mid and Upper Bay landings from Area 1B prior to 1997 (Figure 8).

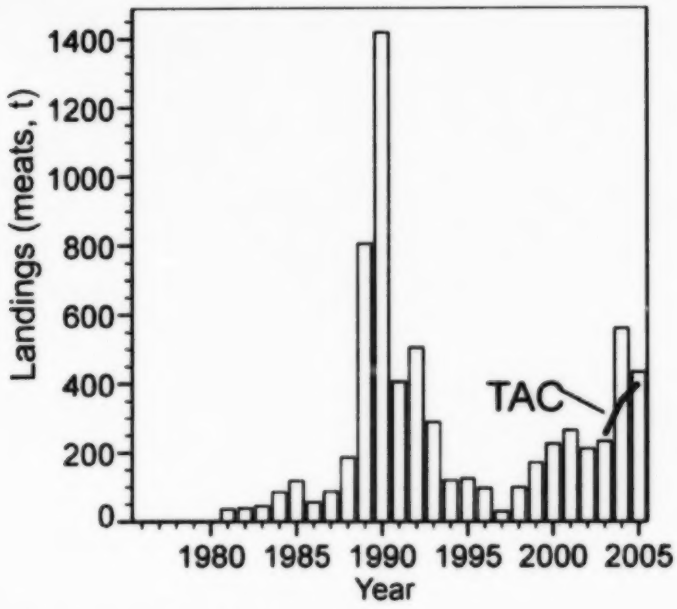


Figure 8. Scallop landings (meats, t) in SPA 1B.

Resource Assessment

In SPA 1B, the Full Bay log records do not contain complete data (location, catch and effort) until 1982. For the Mid Bay fleet, CPUE can only be calculated for the period since 1992, and for the Upper Bay fleet since 1997.

Commercial catch rates show an increasing trend from the low in 1997 (Figure 9), but not the large peak observed in 2002 in SPA 1A (See Figure 3). Commercial catch rate has declined the last two years, but is still above the median level.

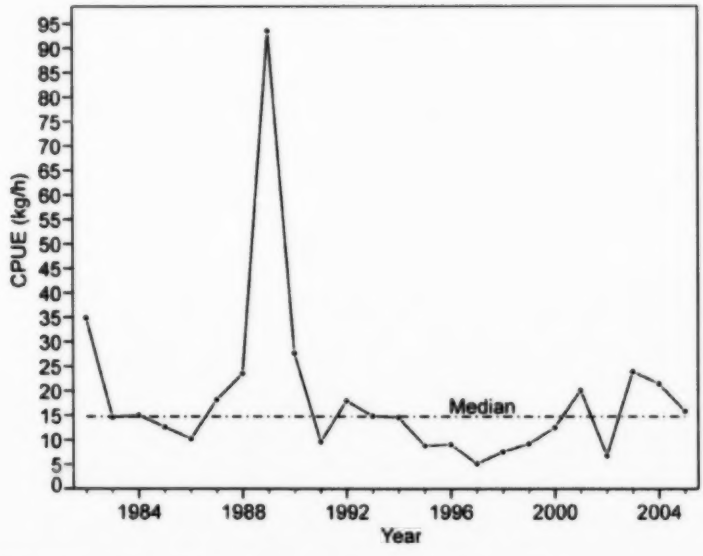


Figure 9. Commercial catch rate (kg/h) for Scallop Production Area 1B.

In SPA 1B, resource surveys have not consistently covered the whole area. Due to research vessel problems, the survey only covered the Cape Spencer grounds in 2004. SPA 1B was more completely surveyed with a commercial vessel in 2005 (See Figure 4).

The **Cape Spencer** and Upper Bay areas have the most consistent coverage and the longest time series in this area. Other areas within SPA 1B have been covered as time was available during the Bay of Fundy surveys.

Mean numbers per tow of commercial-sized scallops in the Cape Spencer Area showed an increasing trend to 2004 as moderate year-classes entered the fishery (Figure 10). Recruitment in this area has remained relatively constant, with little sign of the 1998 year-class observed in the 8-16 mile area of SPA 1A. The 2005 survey found lower numbers of commercial sized scallops than the previous three years, but above the levels seen in 1997–1999.

The height frequencies show the moderate strength year-class that recruited to the fishery in 2000 (Figure 11). Recruitment and growth have kept up with removals from the stock, resulting in an increasing trend in the abundance of commercial-sized scallops. The 2004 survey showed a mode of small (approx. 35 mm shell height) scallops located in a band along the New Brunswick side of the Mid Bay line. This mode appears much smaller at approximately 55 mm, in the 2005 survey and will have less of an impact than originally anticipated when it recruits to the fishery in 2006.

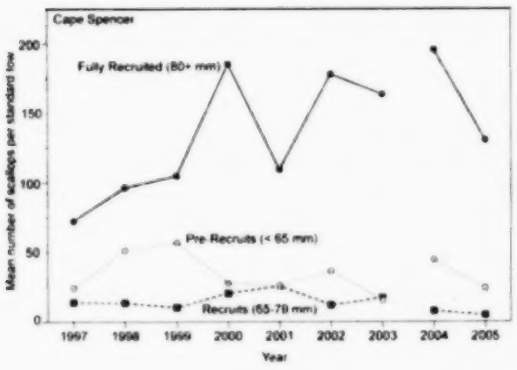


Figure 10. Survey indices (mean no./std. tow) for the Cape Spencer area. The break in the survey series indicates the change in timing of the survey. Surveys were conducted in June from 1981 to 2003 and in August/September in 2004 and 2005.

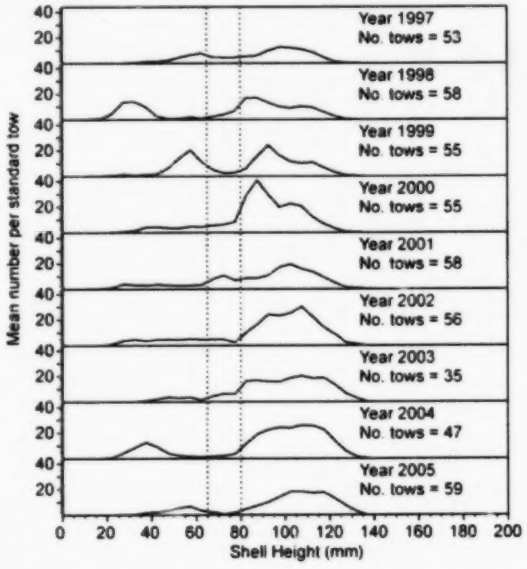


Figure 11. Survey indices (mean no./std. tow) by shell height for the Cape Spencer area. Surveys were conducted in May/June from 1981 to 2003 and in August/September in 2004 and 2005.

Surveys have been conducted in the **Upper Bay** area at varying times of year since 1998.

The 2005 survey shows a large decline in the abundance of commercial-sized (greater than 80 mm shell height) scallops, but an increase in scallops less than 65 mm shell height since 2003 (Figure 12).

The survey shell height frequency data show that the increase in pre-recruits is made up of two modes, one at 30 and another at 55 mm shell height (Figure 13). These year-classes were found in only a few tows during the survey and so may not be widespread.

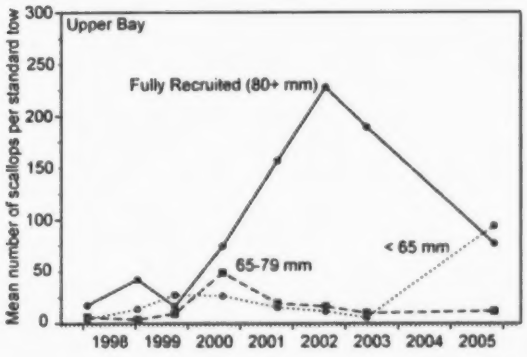


Figure 12. Survey indices (mean no./std. tow) for the Upper Bay area.

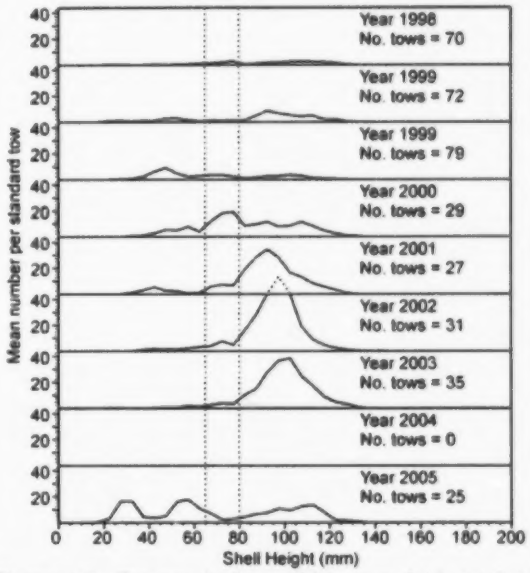


Figure 13. Survey indices (Mean no./std. tow) by shell height for the Upper Bay area.

Conclusions and Advice

In SPA 1B there are signs of two above average year-classes evident in this year's survey. However the year-class that appeared to be above average in last year's survey appears to be average in this year's survey. In light of the possibility these year-classes may be overestimated, the advice is to take a cautious approach and not change the allowable catch until the sizes of these year-classes are better defined.

Other Considerations

Objectives and associated reference points are being developed through discussions between DFO and industry. Acceptance of a reference level biomass as a management strategy implies a positive relationship between that reference level and future recruitment success. Such a relationship has not yet been satisfactorily established. Industry considers that such a strategy can increase the risk of episodic die-offs, especially at high scallop densities. Implementing research and monitoring aimed at establishing the relationship between scallop biomass and recruitment both within current SPAs and within the Bay of Fundy meta-population as a whole is essential. In addition research and monitoring focussing on determining the conditions resulting in episodic die-offs is warranted.

In order to maximise yield-per-recruit, the impact of fishing practices on the mortality of recruits and pre-recruit scallops needs to be investigated.

Delayed reporting (logbooks) by the Mid and Upper Bay fleets, although improving, continues to be a problem.

The industry participants at the meeting brought up the following points:

- The Full Bay Scallop Association recommends that the *F.V. Royal Fundy* or some other commercial scallop dragger continue to conduct the scientific scallop surveys in the Full Bay area now and in the future. By using the commercial vessel to do the survey, the scientists were able to cover more stations thus providing better surveys.
- The Full Bay Scallop Fleet recommends that additional government funding needs to be provided for scallop research.

SPA 3 – Brier Island, Lurcher Shoal, and St. Mary's Bay

The Fishery

Although scallops can be found throughout most of the area, there are three main beds, those around Lurcher Shoal, below Brier Island, and in St. Mary's Bay. St. Mary's Bay (formerly SPA 7) was combined with SPA 3 in 1999 for management purposes with a single TAC. The lobster fishery influences the scallop-fishing season throughout this area.

In the 1950's and 1960's, this area was heavily exploited but subsequently, fishing was minimal until 1980, when both the inshore and offshore fleets fished the area until 1986. In 1986, an agreement was reached between the two fleet sectors to establish separate inshore and offshore grounds, north and south of latitude 43°40'N, respectively. This agreement excluded the offshore fleet sector from the area now defined as SPA 3.

Landings in SPA 3 increased each year from 1991 to 1994, reaching a high of 1439 t (Figure 14). Landings declined from 1995 until 1998. However, there is uncertainty about the landings from 1991 to 1996, due to misreporting.

The landings for SPA 3 and 7 have been combined since 1999. There were serious doubts raised about whether all of the landings reported in 1999 for SPA 3 came from this area. There does not appear to be any reason to suspect that landings reported to SPA 3 in subsequent years were from other areas. In recent years (2001-2004) effort has been redirected from SPA 3 to other areas.

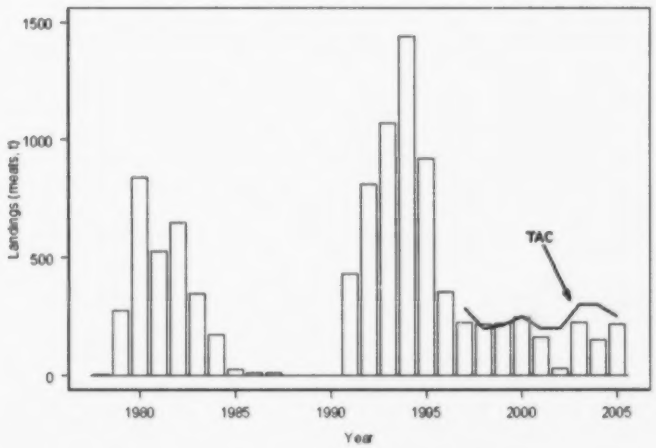


Figure 14. Scallop landings (meats, t) in Scallop Production Area 3.

Landings (meats, t)

Year	Avg. 1997–01	2002	2003	2004	2005	2006
TAC	230	200	300	300	200	50[1]
Landings	216	31	225	151	208	12[2]

1. Interim.
2. Preliminary landings as of 14 November 2005.

Landings in 2005 were 208 t against a TAC of 200 t. An interim TAC of 50 t was set for the 2005/2006 season and unlike recent years fishing occurred in October in 2005.

Resource Assessment

Commercial catch rate averaged 16.7 kg/h in 2005, compared to 22.1 kg/h in 2004 but is just above the median catch rate for the series (14.5kg/h; Figure 15).

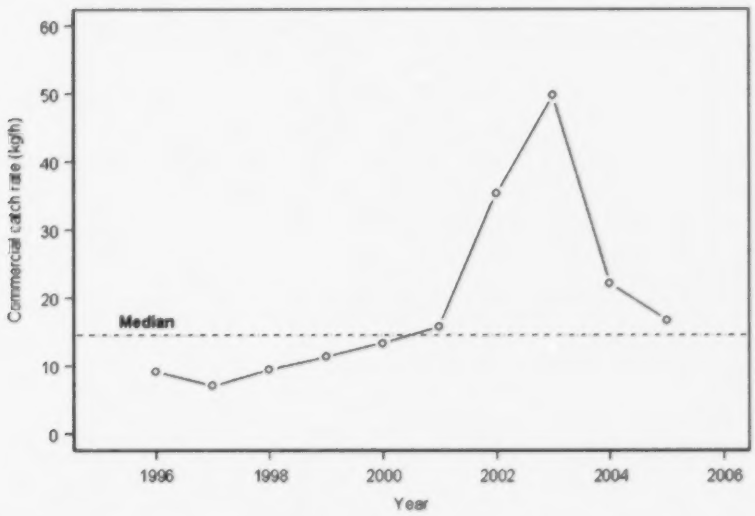


Figure 15. Commercial catch rate (kg/h) for the Brier/Lurcher portion of Scallop Production Area 3.

Annual research vessel surveys have been conducted in Brier Island and Lurcher Shoal area each August from 1991 to 2003. Surveys in SPA 1 and 4 were rescheduled to August in 2004 to avoid problems with lobster gear in June. As a result, the surveys in SPA 3 were conducted in June in 2004 and 2005. Due to coverage and design, only the results from the 1996 to 2005 surveys are comparable.

The largest concentrations of commercial-size scallops (shell height ≥80 mm) continue to be mainly in the southwest area of Lurcher Shoal (Figure 16). The scallops in this area usually have smaller meat weight-at-shell height than those caught elsewhere in SPA 3 due to lower growth rates in the deeper water.

The distribution of recruits (shell height 65–79 mm) was patchy and mainly in the eastern part of the area (Figure 17). Pre-recruits (shell height < 65 mm) occurred in relatively high densities in the Lurcher Shoal area, however based upon past experience indices for this size range are not very reliable indicators of year-class strength. Three large catches of clappers were made near the western boundary of the survey area but otherwise clappers were of low density and patchy in distribution.

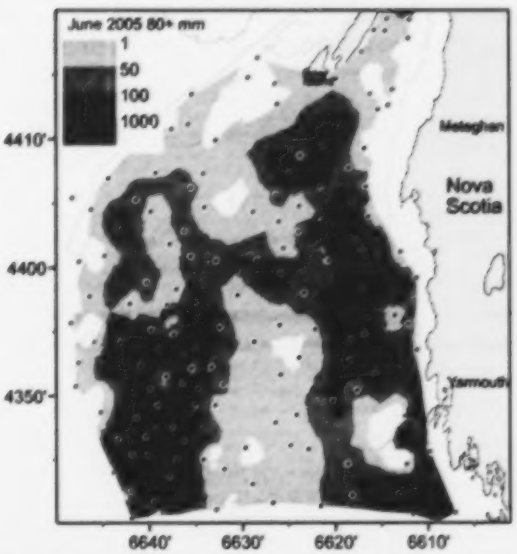


Figure 16. Spatial distribution of scallop catches from the June 2005 survey of the Brier/Lurcher portion of Scallop Production Area 3 for scallops with shell heights greater than 80 mm.

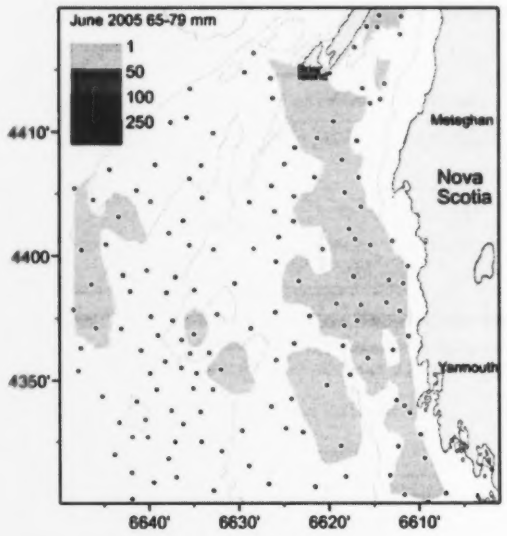


Figure 17. Spatial distribution of scallop catches from the June 2005 survey of the Brier/Lurcher portion of Scallop Production Area 3 for scallops with shell heights 65 to 79 mm.

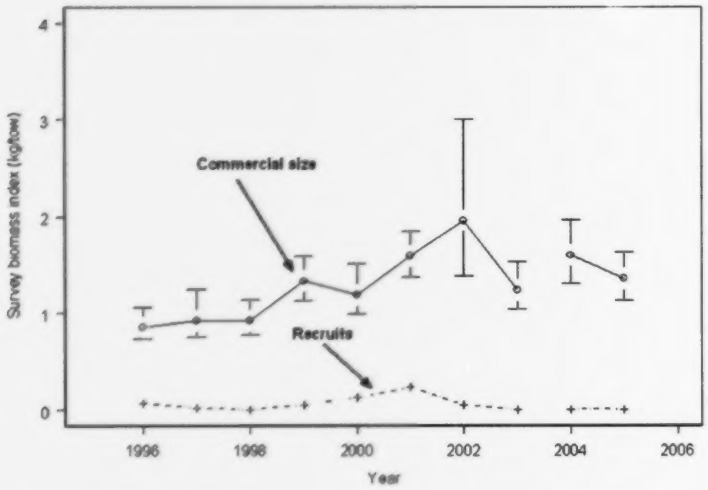


Figure 18. Survey biomass indices for the Brier/Lurcher portion of Scallop Production Area 3. Commercial size index has 95% confidence intervals added. Prior to 2004 the survey was conducted in August, surveys in 2004 and 2005 were conducted in June.

Mean weight per tow from the 2005 survey (1.4 kg/tow) indicated that the biomass of commercial-size scallops declined after 2002, but remained just above the median for the ten-year series (1.3 kg/tow). There appears to be little recruitment for 2006 in the Brier/Lurcher area (Figure 18).

Surveys of St. Mary's Bay have been conducted from 1999 to 2001 inclusive. No surveys were conducted for St. Mary's Bay in 2002 and 2003 due to limited research vessel time. Eighteen stations were completed in St. Mary's Bay in 2004 and 24 in 2005.

The largest concentrations of commercial-size scallops (shell height equal to or greater than 80 mm) were found off of Long Island with smaller patches in the upper part of the Bay (Figure 19). The distribution of recruits (shell height 65-79 mm) was widespread but they were at low densities everywhere (Figure 20). Pre-recruits (shell height less than 65 mm) were widespread but occurred in relatively high densities near Long Island (Figure 21).

Two tows with relatively large numbers of clappers were made off of Long Island and one further up the Bay; there were low densities of clappers elsewhere.

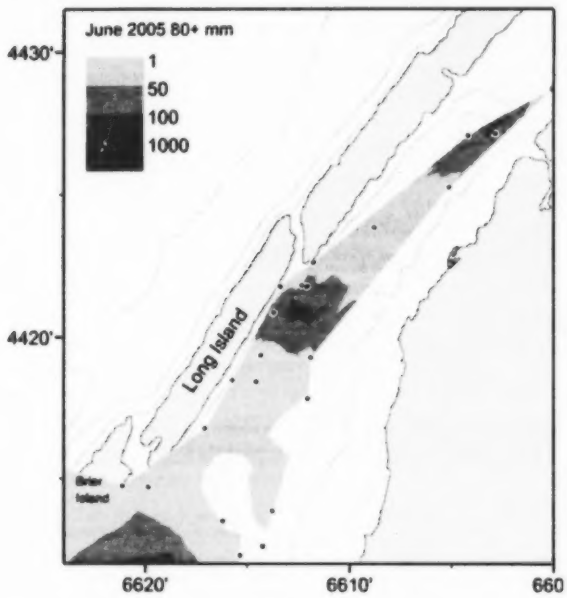


Figure 19. Spatial distribution of scallop catches from the June 2005 survey of the St. Mary's Bay portion of Scallop Production Area 3 for scallops with shell heights equal to or greater than 80 mm.

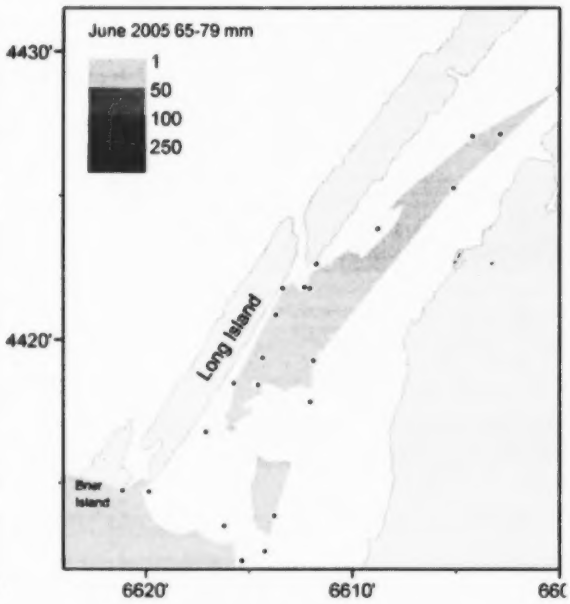


Figure 20. Spatial distribution of scallop catches from the June 2005 survey of the St. Mary's Bay portion of Scallop Production Area 3 for scallops with shell heights from 65 to 79 mm.

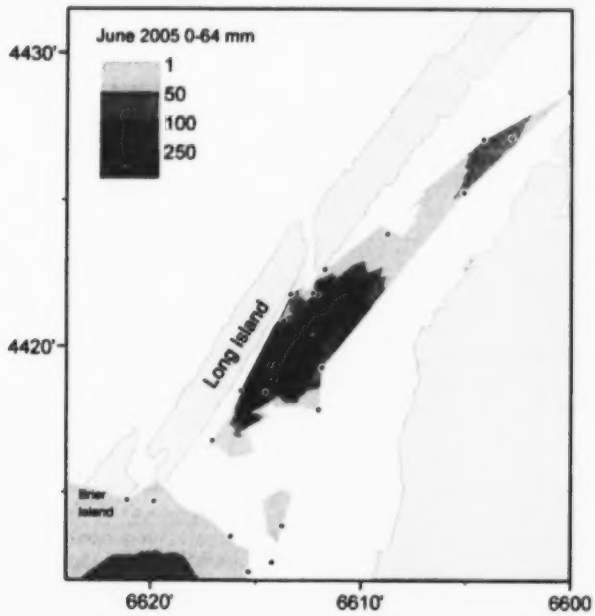


Figure 21. Spatial distribution of scallop catches from the June 2005 survey of the St. Mary's Bay portion of Scallop Production Area 3 for scallops with shell heights less than 65 mm.

Conclusions and Advice

There are no reference points for this fishery. Based upon the survey trends, the population appears to be stable at the 150 to 200 t catch level with the possibility of an above average 2004 year-class that could recruit to the fishery within St. Mary's Bay in 2008.

Other Considerations

Objectives and associated reference points are being developed through discussions between DFO and industry. Acceptance of a reference level biomass as a management strategy implies a positive relationship between that reference level and future recruitment success. Such a relationship has not yet been satisfactorily established. Industry considers that such a strategy can increase the risk of episodic die-offs, especially at high scallop densities. Implementing research and monitoring aimed at establishing the relationship between scallop biomass and recruitment both within current SPA's and within the Bay of Fundy meta-population as a whole is essential. In addition research and monitoring focussing on determining the conditions resulting in episodic die-offs is warranted.

In order to maximise yield-per-recruit, the impact of fishing practices on the mortality of recruits and pre-recruit scallops needs to be investigated.

The industry participants at the meeting brought up the following points:

- The Full Bay Scallop Association recommends that the *F.V. Royal Fundy* or some other commercial scallop dragger continue to conduct the scientific scallop surveys in the Full Bay area now and in the future. By using the commercial vessel to do the survey, the scientists were able to cover more stations thus providing better surveys.
- The Full Bay Scallop Fleet recommends that additional government funding needs to be provided for scallop research.

SPA 4 – Digby

The Fishery

Landing data in what is now SPA 4 are available from 1976 to 2005 (Figure 22). The season extends from 1 October to 30 April. In 2005, the season was extended to May 6th.

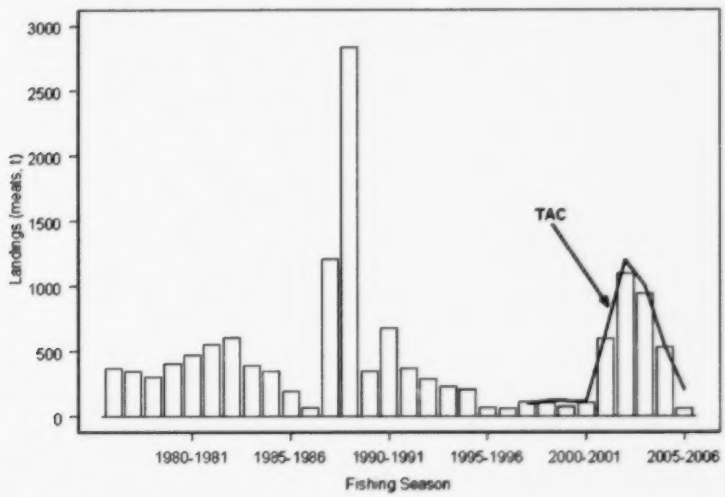


Figure 22. Scallop landings (meats, t) in Scallop Production Area 4.

Landings steadily declined from 1991 to 1995 as the remnants of large year-classes (1984, 1985) were fished down. Portions of what is now SPA 4 were closed in 1995 and 1996 because of low stock levels. The increase in landings starting in 2001 was due to the strong 1998 year-class recruiting to the fishery. In October 2001 fishing was restricted to the Digby Gut up the Bay to Parkers Cove to protect the abundant 1998 year-class. As this year-class grew and recruited to the fishery, fishing occurred throughout area 4.

A total of 945 t was landed against a TAC of 1000 t in 2003/2004. Reasons for the total TAC not being caught include unallocated quota due to ongoing negotiations with First Nations. Landings in 2004/2005 were 535 t against a TAC of 550 t. An interim TAC of 200 t has been set for the 2005/2006 season which opened 1 October 2005.

Landings (meats, t)

Season	Avg. 1997–01	2002/ 2003	2003/ 2004	2004/ 2005	2005/ 2006
TAC	220	1200	1000	550	200[1]
Landings	200	1097	945	535	60[2]

[1] Interim TAC.
[2] preliminary as of 14 November 2005.

Total **effort** (hours) was low in 1995/96 and 1996/97, due to the closures in part of SPA 4, but effort increased thereafter until 1998/1999 (Figure 23). In 2000/01, effort was at its lowest level in 26 years. Current levels of effort are at the second highest in the series.

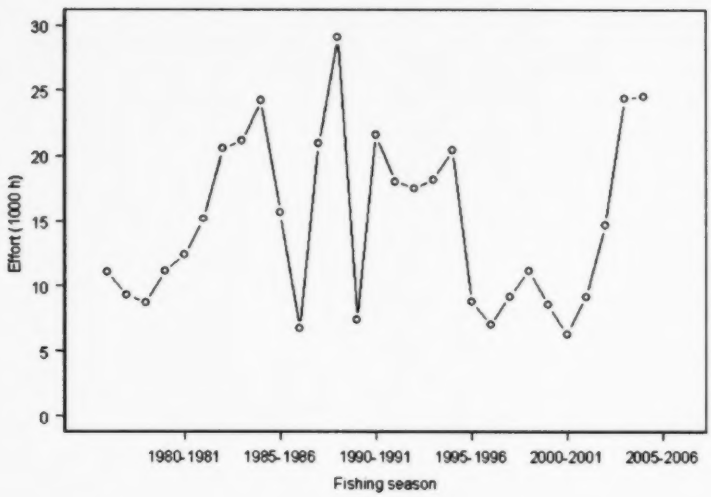


Figure 23. Effort (1000's h) for the scallop fishery in Scallop Production Area 4.

Resource Assessment

Commercial catch rates in 2004/2005 (21.8 kg/h) declined over those from the previous three years (Figure 24) and was near the median for the time-series of 21.3 kg/h. Average catch rates from October 2005 (12.2 kg/h) are less than half the average for the same time in 2004 (27.0 kg/h).

Research vessel surveys, using a consistent stratified random design, have been conducted since 1991. Prior to 1991, surveys were stratified according to the spatial pattern of the preceding year's commercial catch rate. Up to 2003 the surveys have been conducted in June every year, but the expanding distribution of lobster traps in the area necessitated rescheduling the survey to August in 2004. However, survey vessel mechanical problems resulted in the 2004 survey being conducted in September. The 2005 survey of SPA 4 was completed in August as planned.

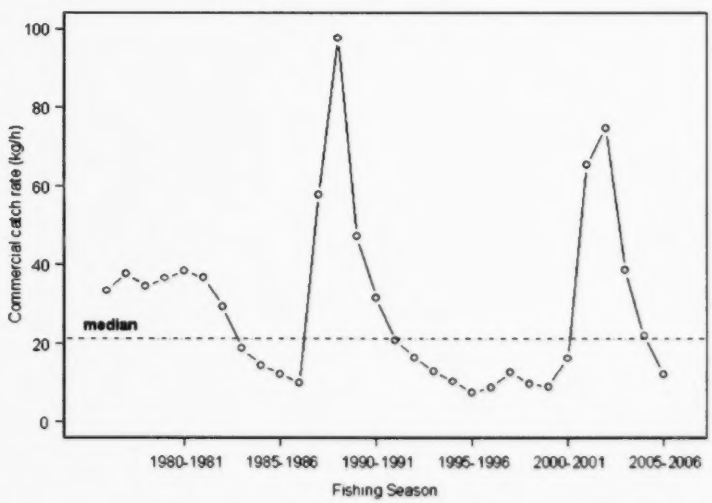


Figure 24. Commercial catch rate (kg/h) for scallops in Scallop Production Area 4.

Previous assessments have reported a strong correlation between survey biomass indices in the current year with the commercial fishery catch rate in the following season. Using a linear relationship based on *CCGV J.L. Hart* points only (1996 to 2004) the predicted commercial catch rate for October 2005 based on the FV Royal Fundy estimate was 10.9 kg/h and the observed catch rate was 12.2 kg/h which was within the 95 percent confidence limits of 8.6 kg/h and 13.2 kg/h (Figure 25). Based upon these results it was assumed that the 2005 **survey estimate was comparable** to previous years' survey estimates using the *CCGV J.L. Hart*.

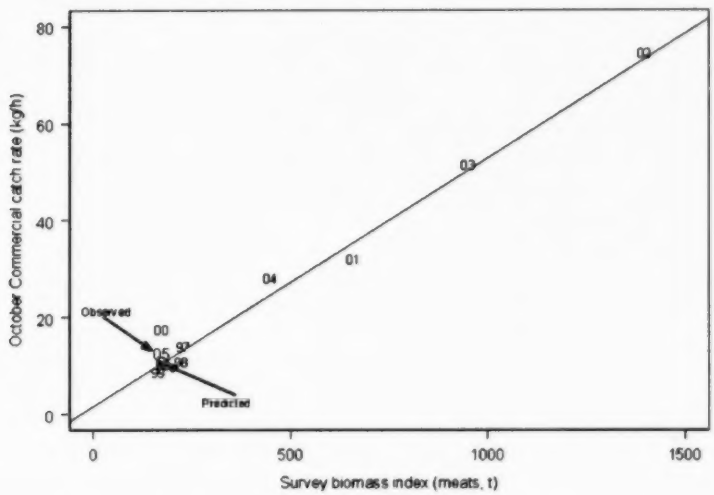


Figure 25. Comparison between summer research survey biomass index with commercial catch rate in October of the same year for Scallop Production Area 4.

In 2005, the main concentration of commercial size scallops (shell height ≥80 mm) continues to be found in the Centreville to Digby gut area (Figure 26). Overall, numbers of commercial size scallops have declined by 45 percent from 2004 with the largest decrease (74%) being observed in the areas shallower than 90 m.

Scallops that will recruit in 2005/2006 (shell height 65 to 79 mm shell height) were marginally higher than in 2004 but were absent from many of shallower areas (Figure 27). For scallops of less than 65 mm, mean numbers in 2005 are slightly higher than in 2004, but still low compared to recent years (Figure 28).

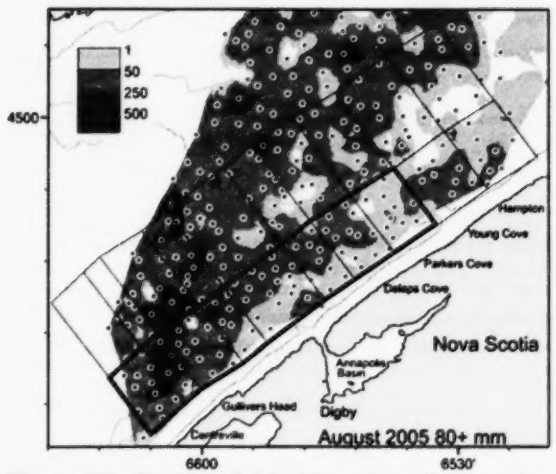


Figure 26. Spatial distribution of scallop catches from the August 2005 survey of Scallop Production Area 4 for scallops with shell heights equal to or greater than 80 mm. The outer boundary of the SPA 4 area is indicated on the map.

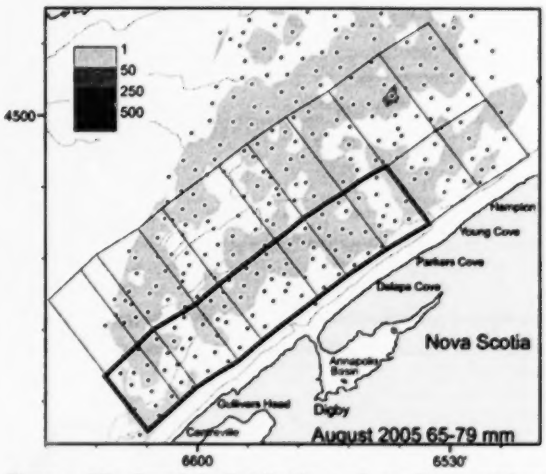


Figure 27. Spatial distribution of scallop catches from the August 2005 survey of Scallop Production Area 4 for scallops with shell heights from 65 to 79 mm. The outer boundary of the SPA 4 area is indicated on the map.

Survey numbers indicate that the stronger than average 1998 year-class has been fished down and there are no indications of any substantial recruitment for the next two to three years (Figure 29).

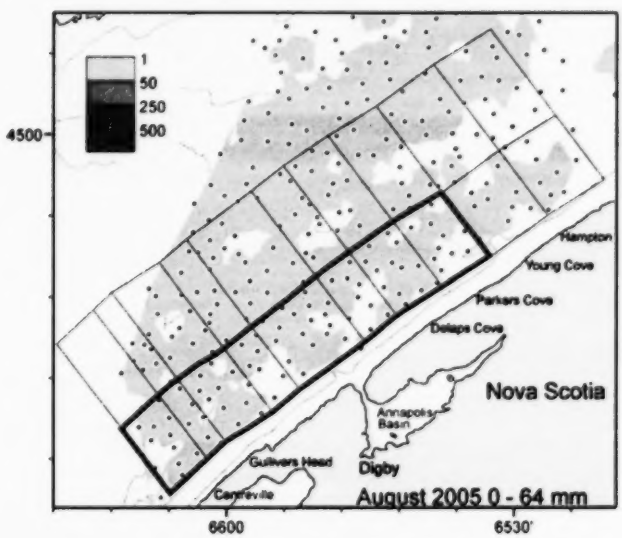


Figure 28. Spatial distribution of scallop catches from the August 2005 survey of Scallop Production Area 4 for scallops with shell heights less than 65 mm. The outer boundary of the SPA 4 area is indicated on the map.

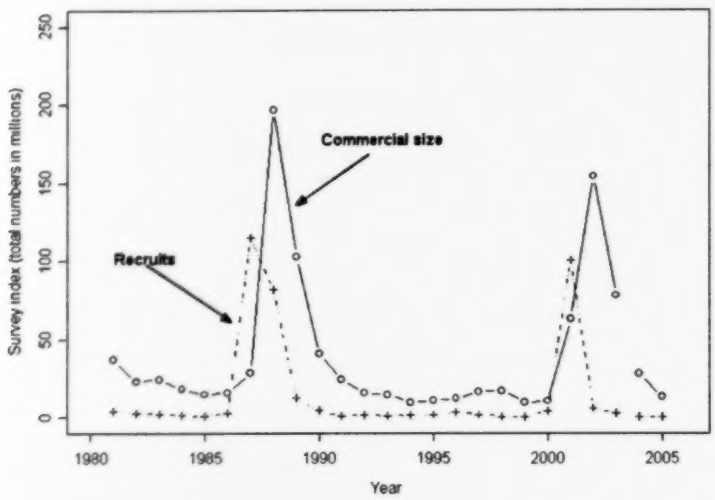


Figure 29. Survey index (total numbers in millions) from research surveys of Scallop Production Area 4. The break in the survey series indicates the change in timing of the survey. Surveys were conducted in June from 1981 to 2003 and in August/September in 2004 and 2005.

The population model described in Smith et al. (2003) was used to analyze the survey and commercial catch data and estimate natural mortality and population biomass. Estimated biomass for commercial size and recruits are presented in Figure 30.

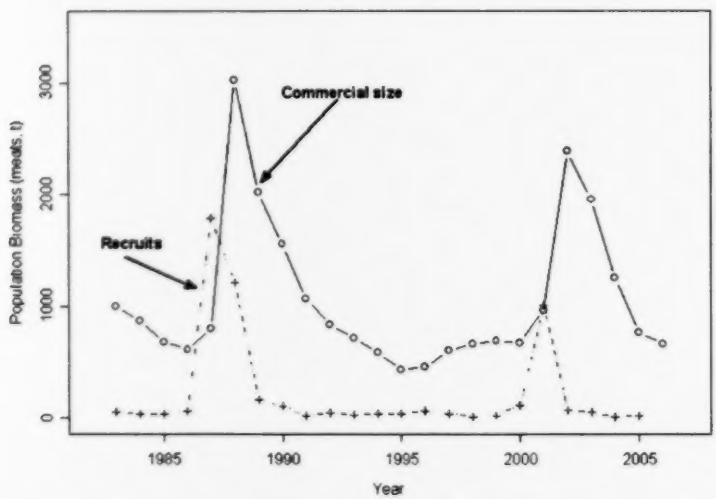


Figure 30. Estimated population biomass (meats, t) for scallops in SPA 4. Point estimates are medians from posterior distributions from the population model.

The model was revised in 2004 to improve its ability to forecast population size for the following year. Differences between predicted and estimated biomass in 2002 partly reflect the increase in growth rate noted in 2001 (Figure 31); a constant growth function was assumed for this model. Another reason for the difference between the two sets of estimates for 2002 and possibly for 2003 may be imperfect corrections for the changing relative behaviour of the lined and unlined survey gear when densities are high. Further analysis of the relative selectivity of the survey gear will have to be conducted to solve this issue.

This population experienced catastrophic natural mortality in 1989, but current estimates of natural mortality remain low.

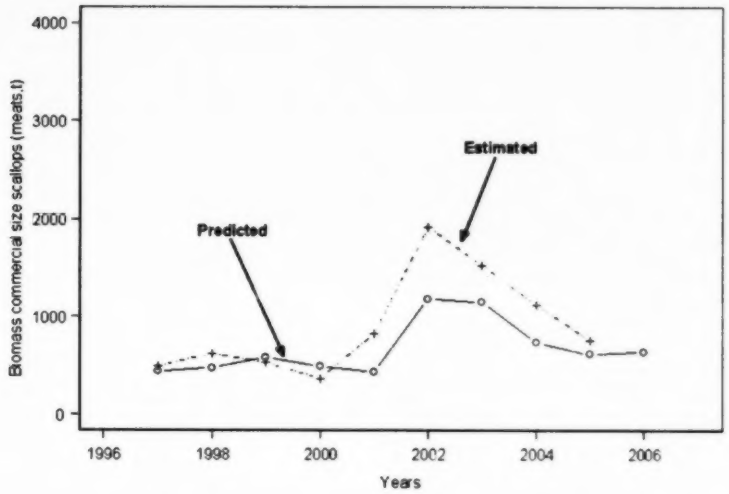


Figure 31. Comparison of predicted mean biomass from the previous year with the estimated median biomass of commercial size scallops in SPA 4 in the current year. Prediction for 2006 made assuming a 2005/2006 catch of 200 t.

Conclusions and Advice

In last year's assessment, exploitation rate was suggested as a fishery indicator with an upper reference point of 0.2 set based on empirical evidence from previous assessments (Lavoie 2004). Given the boom-and-bust cycles observed for this fishery, this indicator was recommended for periods of weak recruitment and low stock biomass. In the table below, the current TAC of 200 t for 2005/2006 is expected to result in an exploitation rate of 0.26 with a probability of 0.63 of exceeding 0.2. The 0.2 exploitation strategy would be 150 t for the current year and no more than 150 t next year. The model predicts that this strategy would result in a modest increase in population biomass after this year's fishery and next year's fishery. All catches below these levels should result in increases in population biomass.

		Catches in 2006/2007				
Catch in	Pr(e>0.2)	Pr(e>0.2) (exploitation)				
2005/06	(exploitation)	50 t	100 t	150 t	200t	250 t
100 t	0.31 (0.13)	0.14 (0.06)	0.34 (0.13)	0.49 (0.19)	0.60 (0.26)	0.69 (0.32)
150 t	0.49 (0.20)	0.18 (0.07)	0.37 (0.14)	0.52 (0.21)	0.63 (0.28)	0.71 (0.35)
200 t	0.63 (0.26)	0.23 (0.08)	0.41 (0.15)	0.54 (0.23)	0.65 (0.30)	0.73 (0.38)
250 t	0.74 (0.36)	0.29 (0.09)	0.44 (0.17)	0.57 (0.25)	0.67 (0.33)	0.75 (0.42)

Other Considerations

Objectives and associated reference points are being developed through discussions between DFO and industry. Acceptance of a reference level biomass as a management strategy implies a positive relationship between that reference level and future recruitment success. Such a relationship has not yet been satisfactorily established. Industry considers that such a strategy can increase the risk of episodic die-offs, especially at high scallop densities. Implementing research and monitoring aimed at establishing the relationship between scallop biomass and

recruitment both within current SPAs and within the Bay of Fundy meta-population as a whole is essential. In addition research and monitoring focussing on determining the conditions resulting in episodic die-offs is warranted.

In order to maximise yield-per-recruit, the impact of fishing practices on the mortality of recruits and pre-recruit scallops needs to be investigated.

The industry participants at the meeting brought up the following points:

- The Full Bay Scallop Association recommends that the *F.V. Royal Fundy* or some other commercial scallop dragger continue to conduct the scientific scallop surveys in the Full Bay area now and in the future. By using the commercial vessel to do the survey, the scientists were able to cover more stations thus providing better surveys.
- The Full Bay Scallop Fleet recommends that additional government funding needs to be provided for scallop research.

SPA 5 – Annapolis Basin

The Fishery

This is a small fishery with a season running from 1 January to 31 March. In recent years, landings have varied between 2 and 20 t (Figure 32).

Landings dropped in 2002 to 2.3 t mainly due to increased effort directed to SPA 4 in the winter. Increased landings in 2003 and 2004 were due to strong recruitment of 1999 and 2000 year-classes. Landings in 2005 were 13.3 t against a TAC of 10 t.

Landings (meats, t)

Season	Avg. 1997–01	2002	2003	2004	2005
TAC	11.4	10	10	25	10
Landings	10.7	2.3	12.2	20.4	13.3

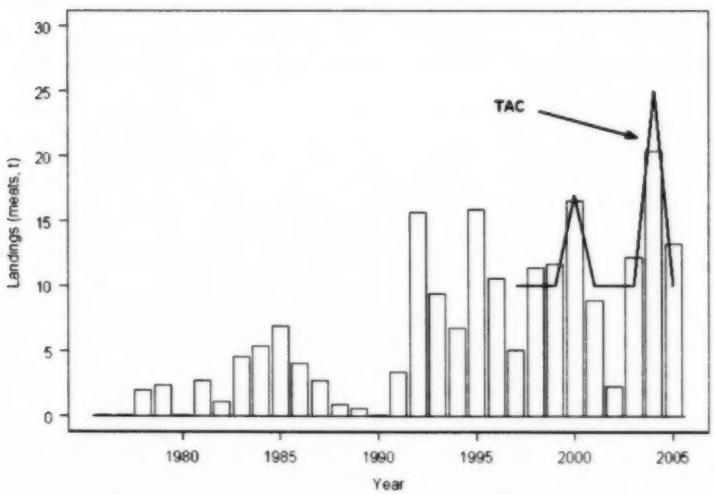


Figure 32. Scallop landings (meats, t) in Scallop Production Area 5.

Resource Assessment

Commercial catch rate in 2005 (26.1 kg/h) was lower than that observed during the past three years but was still above the long term median of 21 kg/h (1977–2005; Figure 33).

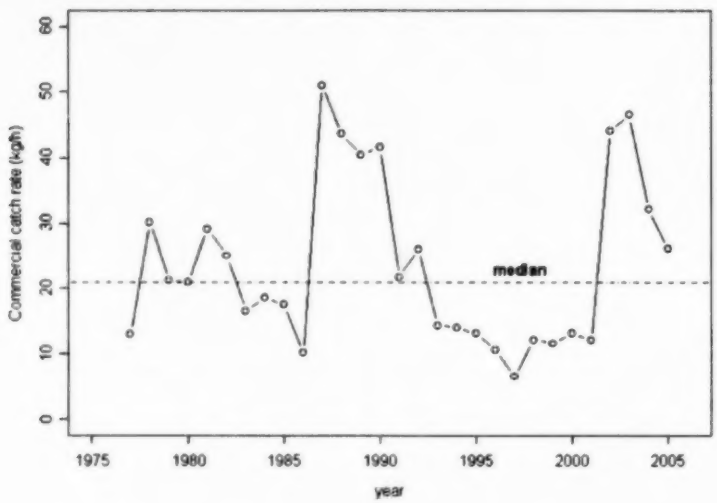


Figure 33. Commercial catch rate (kg/h) for Scallop Production Area 5.

Research vessel surveys have been conducted on a regular basis in Annapolis Basin every June since 1997 in conjunction with the SPA 1 and 4 surveys. The rescheduling of these surveys in 2004 to August and then to September resulted in the 2004 SPA 5 survey also being conducted in September. In 2005, the SPA 5 survey was completed in June.

For the 2005 survey, more than one half of the tows had catches exceeding 100 commercial-size scallops (shell height ≥80 mm) and these were widespread in distribution. For recruits (shell height 65 to 79 mm) all of the tows had <35 scallops while pre-recruits (shell height < 65 mm) had 2 tows greater than 100.

Mean number of commercial-size scallops per tow in 2005 was unchanged from 2004 (Figure 34). The mean number of recruits and pre-recruits per tow in 2005 were similar to those observed during most of the time series (the exception being 2002 -- a year of particularly high abundance).

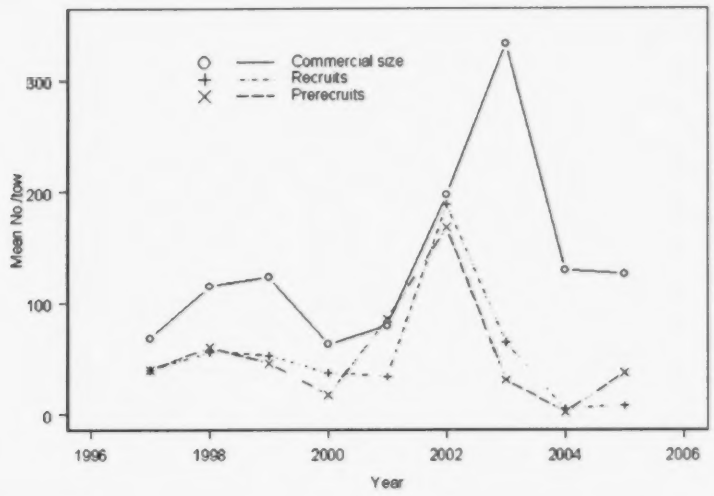


Figure 34. Survey indices (Mean number per tow) for Scallop Production Area 5.

Conclusions and Advice

A population model has yet to be developed for this SPA. Based on the survey, the stock status of commercial size scallops has remained virtually unchanged after a 2005 fishery of 13 t. Survey estimates indicate that the commercial size portion of the population (126/tow) is just above the 1997–2005 median (123/tow) but little recruitment is expected for the next two years. The TAC for 2006 should not exceed the average over the low abundance periods (1997 to 1999) of 10 t.

Other Considerations

Objectives and associated reference points are being developed through discussions between DFO and industry. Acceptance of a reference level biomass as a management strategy implies a positive relationship between that reference level and future recruitment success. Such a relationship has not yet been satisfactorily established. Industry considers that such a strategy can increase the risk of episodic die-offs, especially at high scallop densities. Implementing research and monitoring aimed at establishing the relationship between scallop biomass and recruitment both within current SPAs and within the Bay of Fundy meta-population as a whole is essential. In addition research and monitoring focussing on determining the conditions resulting in episodic die-offs is warranted.

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- The Full Bay Scallop Association recommends that the *F.V. Royal Fundy* or some other commercial scallop dragger continue to conduct the scientific scallop surveys in the Full Bay area now and in the future. By using the commercial vessel to do the survey, the scientists were able to cover more stations thus providing better surveys.
- The Full Bay Scallop Fleet recommends that additional government funding needs to be provided for scallop research.

SPA 6 – Grand Manan and Southwest New Brunswick

The Fishery

The areas around Grand Manan and off southwest New Brunswick are designated SPA 6. This area is further divided into SPA 6A, 6B and 6C (see detailed map on last page, Figure 42).

Landings (tonnes of meats)

Year	Avg. 1997-01	2002	2003	2004	2005
TAC	151	195	195	195	195
Landings	143	128	89	82	88

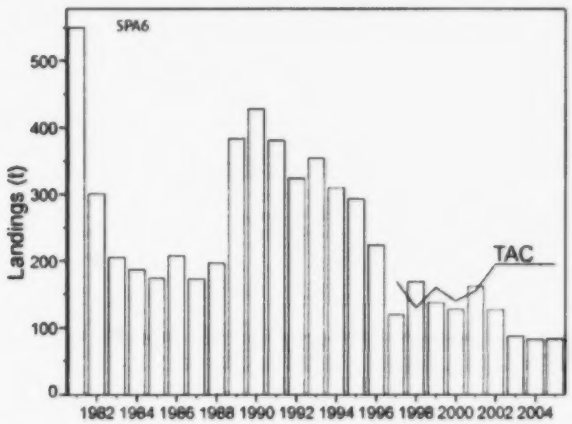

Figure 35. Scallop landings (meats, t) in Scallop Production Area 6.

The 2005 SPA 6 quota for the Full Bay fleet was 50 t with a maximum of 30 t from SPA 6B+6C the same as in 2004 (Figure 35). Full Bay landings by area for 2005 were 0.5 t, 8.8 t and 0.5 t for SPA 6 A, B and C, respectively.

The 2005 quota for the Mid Bay fleet was 145 t. This was split 105 t for 6B and 6C, and 40 for 6A. Mid Bay landings for 2005 by area were 35.4 t, 26.1 t and 16.7 t for SPA 6A, B and C, respectively.

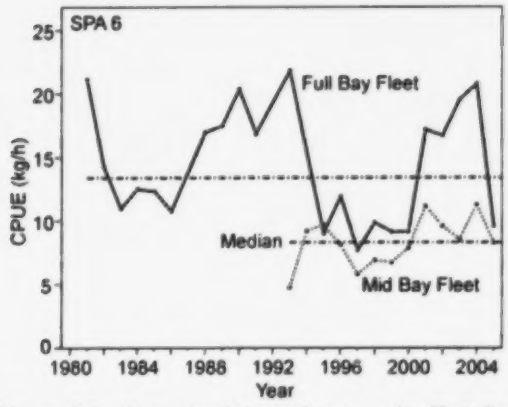

Figure 36. Commercial catch per unit effort (kg/h) by fleet.

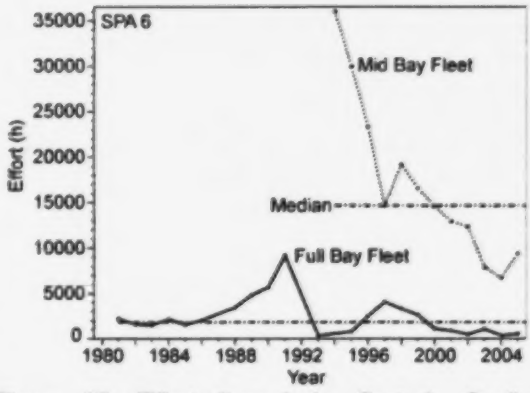

Figure 37. Effort (hours) by fleet in Scallop Production Area 6.

Commercial catch rates for the Full Bay fleet have been fluctuating with low effort. CPUE for the Mid Bay Fleet is fluctuating at a lower rate at or above the 1993-2005 median (Figure 36).

Effort for the Mid Bay fleet has declined dramatically from 1993 (Figure 37).

Resource Assessment

Research vessel (RV) surveys were conducted annually from 1979 to 1991. A new survey series with a different design was initiated in 1996. From 1997 to 1999, SPA 6C was not covered by the survey. There was no research survey in 2004 due to vessel problems, and a survey with a commercial vessel in 2005 was incomplete (Figure 38).

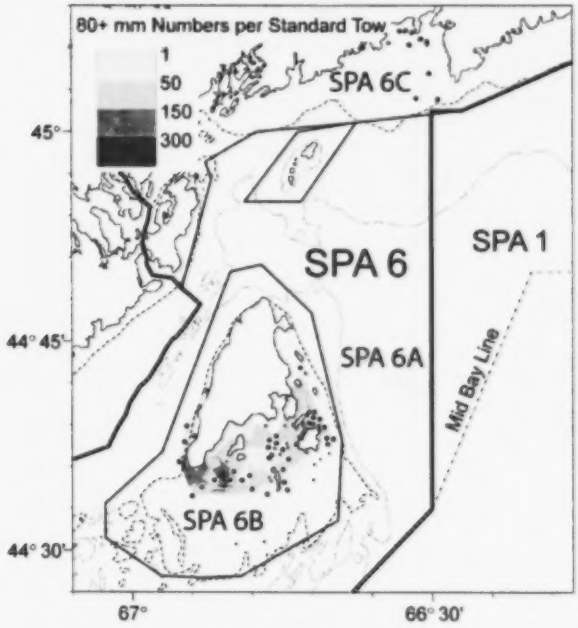

Figure 38. Map of commercial size scallops (shell height equal to or greater than 80 mm) caught in the 2005 survey of Scallop Production Area 6.

Comparing the survey catch rates through time for SPA 6B in the area where the 2005 survey coverage occurred, shows the abundance of commercial-sized (80+ mm shell height) scallops has remained steady, but the abundance of smaller scallops remains low (Figure 39). This decline in the number of small scallops in 2005 is supported by the size frequency data with the lowest numbers of scallops less than 80 mm observed since 1997 (Figure 39).

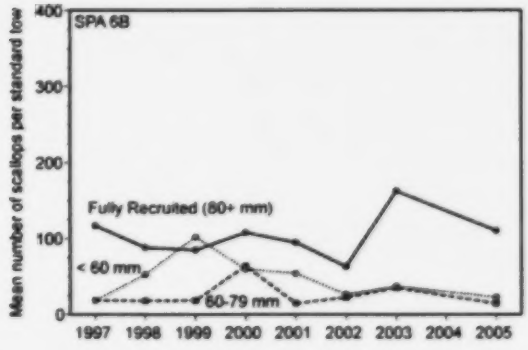

Figure 39. Survey indices (mean no./tow) for Scallop Production Area 6B.

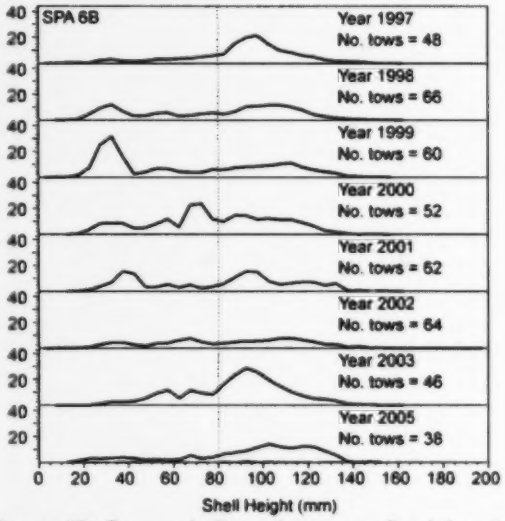

Figure 40. Survey indices (mean no./tow) by shell height for Scallop Production Area 6B.

Meat weight sampling provides information on the sizes of scallops being landed, and is used to monitor the proportion of meats less than 8 and 11 g in the catch.

Samples in 2005 indicated that the fishery in SPA 6 has been relying more on smaller scallops than it did in 2004 during Jan–Mar (Figure 41). One sample in SPA 6C indicated that the majority of the catch that sample came from consisted of scallop meats less than 11 grams. Only one sample was taken in September, but was made up of larger scallops. The meat weight samples do not indicate that a strong year-class recruited to the fishery in 2005.

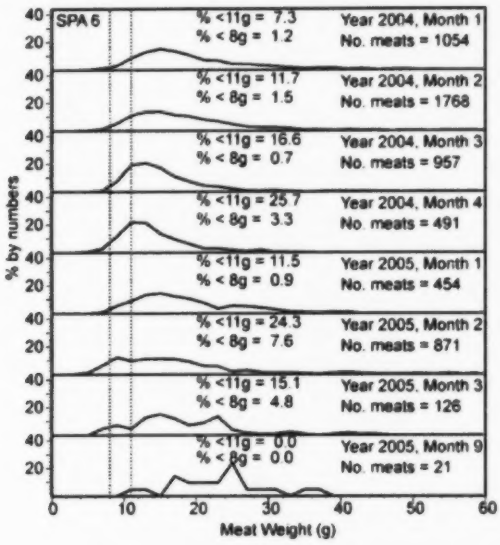
SPA 6
% <11g = 7.3
% < 8g = 1.2
Year 2004, Month 1
No. meats = 1054
% <11g = 11.7
% < 8g = 1.5
Year 2004, Month 2
No. meats = 1768
% <11g = 16.6
% < 8g = 0.7
Year 2004, Month 3
No. meats = 957
% <11g = 25.7
% < 8g = 3.3
Year 2004, Month 4
No. meats = 491
% <11g = 11.5
% < 8g = 0.9
Year 2005, Month 1
No. meats = 454
% <11g = 24.3
% < 8g = 7.6
Year 2005, Month 2
No. meats = 871
% <11g = 15.1
% < 8g = 4.8
Year 2005, Month 3
No. meats = 126
% <11g = 0.0
% < 8g = 0.0
Year 2005, Month 9
No. meats = 21
% by numbers
Meat Weight (g)

Figure 41. Size frequencies for meat weight sampling in SPA 6 for 2004 and 2005.

Conclusions and Advice

Most of the stock indicators show no signs of good recruitment, and a stock of fully recruited scallops that is being fished down. The lack of effort by the Mid Bay fleet in 2005 suggests that there was no strong recruitment to the SPA 6 fishery during 2005 in the portions not covered by the survey.

The population has appeared stable with removals in the range of 80 to 90 t per year for the last three years. The survey coverage of part of SPA 6B shows no sign of recruitment. The advice is that catch should not exceed 80 t in 2006.

Other Considerations

Objectives and associated reference points are being developed through discussions between DFO and industry. Acceptance of a reference level biomass as a management strategy implies a positive relationship between that reference level and future recruitment success. Such a relationship has not yet been satisfactorily established. Industry considers that such a strategy can increase the risk of episodic die-offs, especially at high scallop densities. Implementing research and monitoring aimed at establishing the relationship between scallop biomass and recruitment both within current SPAs and within the Bay of Fundy meta-population as a whole is essential. In addition research and monitoring focussing on determining the conditions resulting in episodic die-offs is warranted.

In order to maximise yield-per-recruit, the impact of fishing practices on the mortality of recruits and pre-recruit scallops needs to be investigated.

Although improving, there are still problems with late submissions of monitoring documents.

The industry participants at the meeting brought up the following points:

- The Full Bay Scallop Association recommends that the *F.V. Royal Fundy* or some other commercial scallop dragger continue to conduct the scientific scallop surveys in the Full Bay

area now and in the future. By using the commercial vessel to do the survey, the scientists were able to cover more stations thus providing better surveys.

- The Full Bay Scallop Fleet recommends that additional government funding needs to be provided for scallop research.

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ISSN 1480-4913 (Printed)
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CORRECT CITATION FOR THIS PUBLICATION

DFO, 2005. Stock Assessment Report on Scallops (*Placopecten magellanicus*) in Scallop Production Areas 1 to 6 in the Bay of Fundy. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/072.

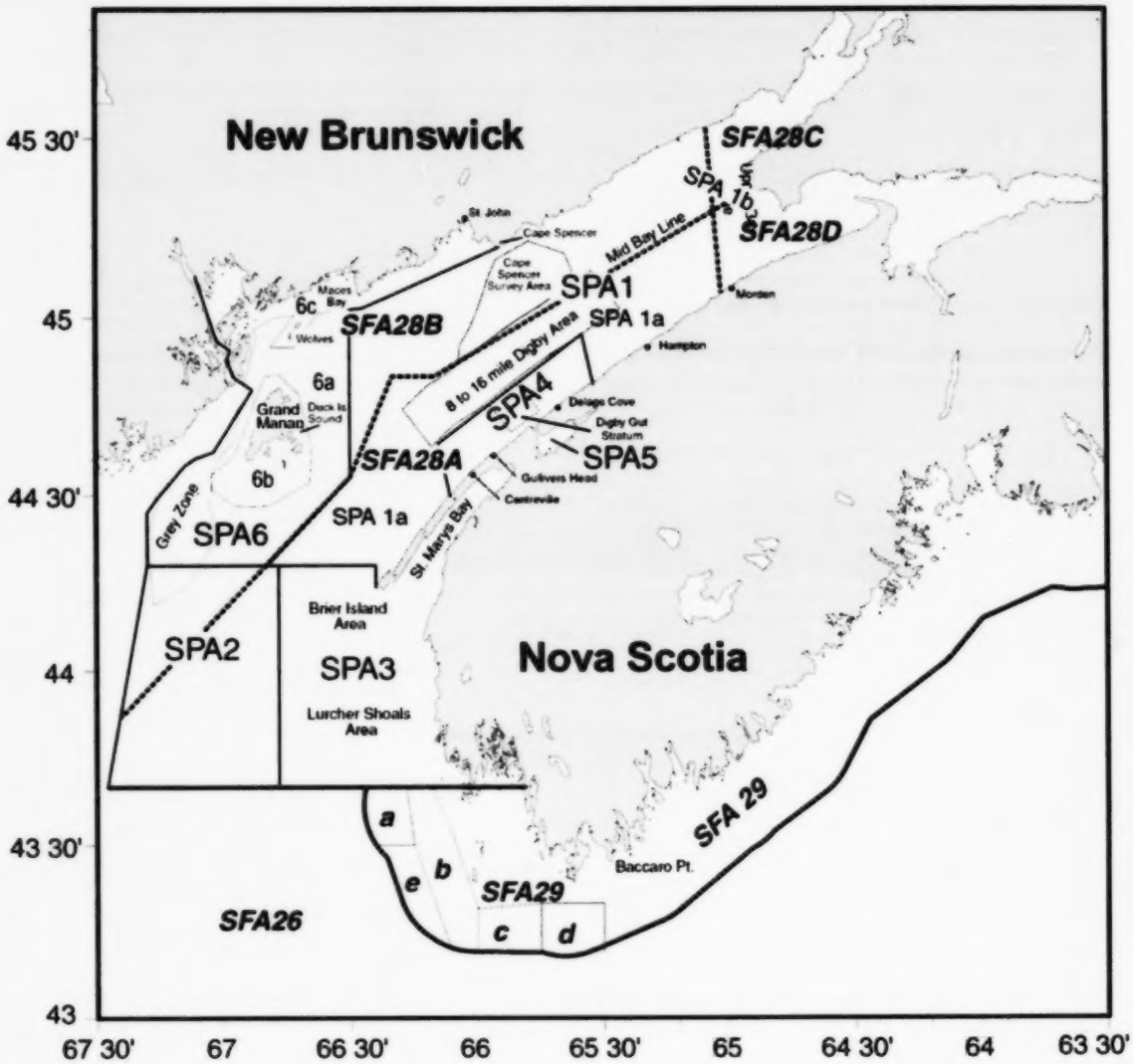

Figure 42. Locations and Place Names used in this Science Advisory Report.